HydroAir Power Take Off

DOE Award: EE0006609

Marine and Hydrokinetics Program

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Siemens Government Technologies

Project Overview

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

Project Summary

Design, construct, and test a full-scale 500kW HydroAir turbine and Power Take Off (HAT PTO). The HAT PTO will utilize the volumetric airflow and pressure transmitted from an Oscillating Water Column (OWC) on the Ocean Energy (OE) buoy as the energy source. Operational deployment is planned at the Navy's grid-connected Wave Energy Test Site (WETS) in late FY19 for system operations/validation.

Project Objective & Impact

Objectives:

- Improved efficiency in air turbines being utilized in wave energy devices by:
- Guide vanes relocated away from the rotor blades reducing obstruction in exit velocities of the air leaving the blade to reduce pneumatic losses
- Single rotating component (rotor) in the primary mover to the generator
- Unidirectional flow without requiring moving guide vanes to aid in same rotating direction of rotor

Impact:

- Reliable and optimized design validating operations over broader range of waves with higher efficiency for higher average power outputs
- Less maintenance with one rotational part in power generation
- Leverage of commercial off the shelf components to lower system cost for grid scale systems

Project Information

Project Principal Investigator(s)

Rod Blunk

WPTO Lead

Erik Mauer
Rajesh Dham

Project Partners/Subs

Ocean Energy

Project Duration

- Project Start Date: OCT 2014
- Project End Date: DEC 2019

Alignment with the Program

Marine and Hydrokinetics (MHK) Program Strategic Approaches

Data Sharing and Analysis

- Foundational and Crosscutting R&D
- Technology-Specific Design and Validation
- Reducing Barriers to Testing

Alignment with the MHK Program

Foundational and Crosscutting R&D

- Drive innovation in components, controls, manufacturing, materials and systems with early-stage R&D specific to MHK applications

- Innovated design in single moving component (rotor) with non-moving guide vanes lowering short & long term maintenance requirements. Guide vanes are designed for uni-directional flow for continuous rotor spinning in the same direction.
- Turbine housing is designed to split in half once installed to allow for rotor replacement allowing rotor to be changed to adjust to wave conditions of various sites minimizing design changes necessary in system design.
- Composite material was used as much as possible in design to lower weight. Ductwork was fiberglass, rotor, rotor blades, guide vanes and shut off valve are all composite material.

Alignment with the MHK Program

Foundational and Crosscutting R&D

- Collaboratively develop and apply quantitative metrics to identify and advance technologies with high ultimate techno-economic potential for their market applications

- Verifying operational metrics at larger scale power application with WEC devices that can provide more constant power output while managing peak wave power. Design WEC devices for power optimization rather than developing for peak wave energy.
- Provide metrics for future wave energy development paths to develop WEC systems designed for achieving higher sustained power operations.

Alignment with the MHK Program

Technology-Specific Design and Validation

- Validate performance and reliability of systems by conducting in-water tests of industry-designed prototypes at multiple relevant scales

- The HydroAir Turbine program had several laboratory test designs that were tested for optimization. Results from these tests developed the current design of the HydroAir Turbine. The prior laboratory units were much smaller in design than the system built for this program. Once the current unit is under test at WETS, the modeling tools will be validated and redefined.

Project Budget

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

Total Project Budget – Award Information		
DOE	Cost-share	Total
$4,500 K	$2,307K	$6,807K

FY14	FY15	FY16	FY17	FY18	FY19 (Q1 & Q2 Only)	Total Actual Costs FY14–FY19 Q1 & Q2 (October 2016 – March 2019)
			Costed	Costed	Costed	Total
$105 K	$ 963K	$1,947 K	$ 451 K	$ 1,422 K	$631 K	$ 5,521 K

Per FY Cost Definitions:

FY14/15 – Preliminary and Detail design of primary components. Discussion for at sea test site (OE 35 Buoy) instead of land base test site (Azores)

FY16- Major component procurement and design changes to integrate onto OE 35 Buoy as test platform

FY17 – Integration efforts to OE 35 Buoy, HydroAir composite material procurement

FY18 – Completion of material procurement and preparation for integration

FY19-FY20 – Integration onto OE 35 buoy and testing

Separate programs for Siemens and Ocean Energy component development with different schedules required various iterations in design and build schedules however the two units are currently integrated and ready to transit to WETS for testing.

Management and Technical Approach

Approach to technical problem:

- Address key issues of WEC for power production (power output, operations and maintenance costs)
- Validation of model to grid scale power systems
- Predictive/design model validation at grid scale power
- Long term testing to validate seasonal way power capabilities while providing power to grid

How addressed:

Wave Energy Device – Combination of Technical Team and Team Members with Maritime operational experience looking at ways to develop designs to address technical problems.

- The team used previous lab testing which showed promise for the HydroAir Turbine design.
- The future full system operations at sea (including ancillary systems) will provide true power production, system required sustained power consumption (self-sustaining base load requirements and overall system efficiency).

Assumptions to be validated:

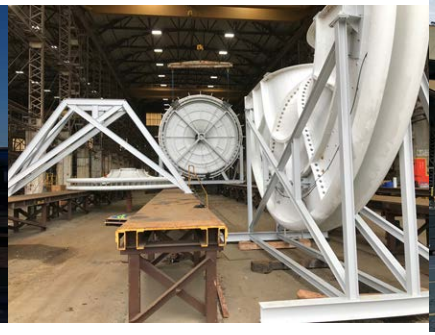
- Higher efficiency WEC over broad range of operating conditions
- Simple design to result in higher reliability, availability and survivability of WEC
- Commercially available systems can be leveraged for WEC devices
- Modeling and scale modelling validation

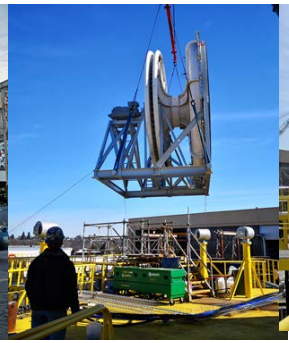
End-User Engagement and Dissemination Strategy

- MHK Industry – First large scale grid connected in the US. Validating that wave energy could be a viable source of renewable power
- Power Providers – 24 hour renewable energy is evaluated, real data on wave energy feasibility on a 24 hour capability to support increased requirements for renewable power generation
- Potential clients – single sites that could leverage wave energy such as:
  - Ocean mobile desalination plants
  - Ocean fisheries
  - Portable power stations in remote areas (locations around remote Alaska or other regions with high fuel prices due to flying/shipping in fuel sources)
- National Labs – review of technical data to evaluate prediction and modeling tools for future developers
- Operational test data will be obtained and provided to industry via the Marine Hydrokinetic Data Repository for WEC industry

Technical Accomplishments

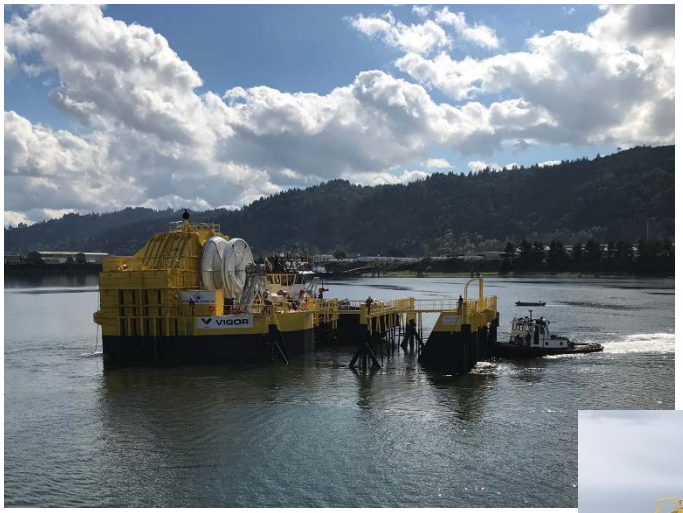
- **Technical accomplishments and progress since December 2016:**
  - Final design of HAT PTO complete
  - Leveraged commercially available systems as much as possible to manufacture PTO.
  - Final manufacturer of HydroAir Turbine completed at Vigor shipyard in Portland OR.
  - HAT PTO system installed and integrated onto the OE 35 Buoy
  - HAT PTO system testing completed in yard (on land) and ready for transport on the OE 35 Buoy to WETS location
  - Overall technology transfer from Siemens partners in UK to Siemens USA for local design and development of US technologies ongoing

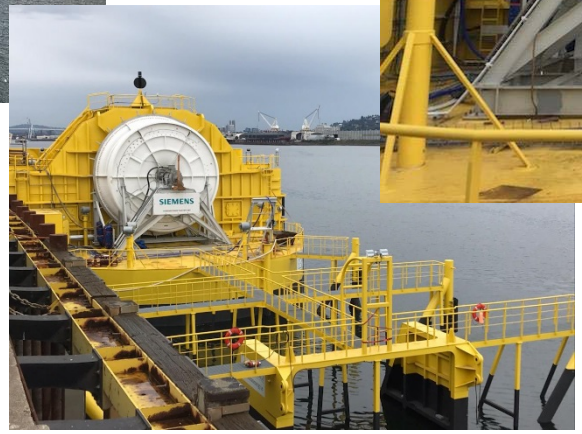





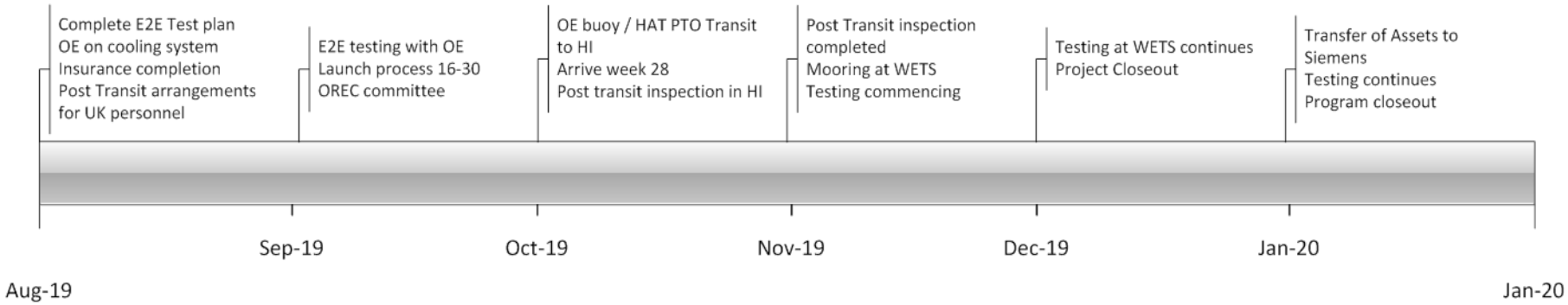

Progress Since Project Summary Submittal

- End to End testing
- Preparation of HAT for Launch and tow to HI
- WETS logistics and installation planning





Future Work



It is anticipated the OE 35 buoy will be moored in late October at WETS in early November for testing and continuous operations with Ocean Energy. Ocean Energy has a 12 month operational test at the WETS location.

Upon Testing a review of operational data versus laboratory testing will be conducted to develop:

- Operational control schemes for higher average power output
- Development of models and laboratory test systems for simulated wave generating pneumatics and control systems
- Future design concepts to increase individual power per unit average electrical output